Astrophysics Research And Analysis

Measuring optical constants of multilayer materials for current and future hard X-ray space telescopes

Completed Technology Project (2015 - 2016)

Project Introduction

With the launch of the NuSTAR space telescope in 2012, a new era in X-ray astronomy began. NuSTAR provides astronomers unprecedented sensitivity in the hard X-ray band, operating from 6-79 keV through the use of multilayers. At lower energies, NuSTAR has an effective area comparable to previous missions, such as the XMM-Newton and Chandra. The overlap allows soft X-ray observations to be combined with hard X-ray ones, providing new constraints on theoretical models and allowing accurate determination of the properties of thermal and non-thermal processes. To successfully predict the performance of a hard X-ray multilayer telescope, precise knowledge of the optical properties of the constituent materials of the multilayers is required. Tungsten and platinum are the two high-density, high-Z materials in the NuSTAR multilayer systems, but early observations with NuSTAR showed that essential atomic parameters , i.e. the optical constants, of these materials are not correct. Specifically, there are significant residuals in spectral fits near the L absorption edges of both materials from 10-14 keV. This situation is not a surprise, as the optical constants for these materials are derived from tabulated photon-interaction cross sections, which does not properly capture the physics of the X-ray absorption fine structure (XAFS). As a result, the NuSTAR team is using an empirical correction to predict performance. The correction does not completely remove spectral features in the 10-14 keV region and is only good for weak sources. We propose to accurately measure the optical constants for tungsten and platinum in the hard X-ray region from 6-28.5 keV, replacing the empirical correction and providing a significant improvement to NuSTAR's response model. The improvement will be achieved by two independent and complementary routes to increase accuracy. One method relies on transmission measurements while the other utilizes reflection measurements. The proposing team leverages extensive experience on the topic of X-ray optical constants and related methodologies and have laid out a carefully designed campaign to determine the optical constants. In addition to providing a significant contribution to an on-going NASA mission, the proposed work will also directly benefit the Japanese (JAXA) ASTRO-H mission and the future European (ESA) mission Athena.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics Research and Analysis

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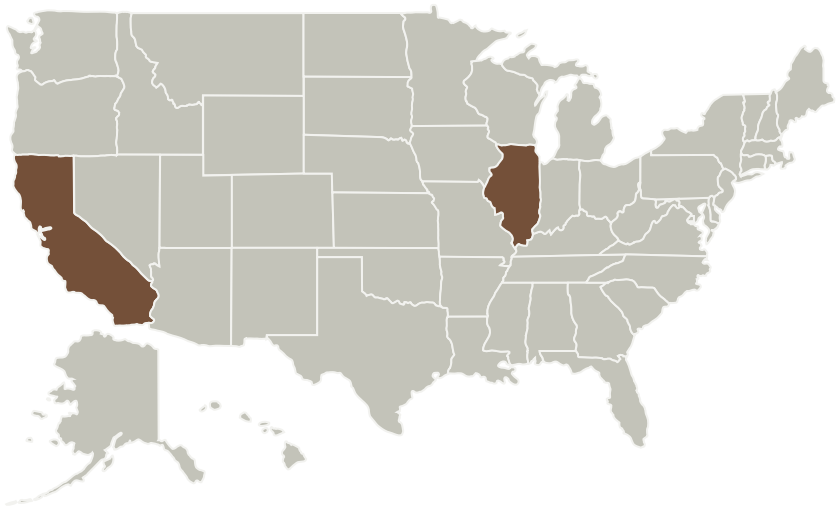
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Department of Energy(DoE)	Supporting Organization	US Government	Washington, District of Columbia
Lawrence Livermore National Laboratory(LLNL)	Supporting Organization	R&D Center	Livermore, California

Primary U.S. Work Locations	
California	Illinois

Project Management

Program Director:
Michael A Garcia

Program Manager:
Dominic J Benford

Principal Investigator:
Nicolai F Brejnholt

Co-Investigators:
Eric Gullikson
Finn E Christensen
Lahsen Assoufid
Scott W Tyler
Michael J Pivovaroff
Regina Soufli

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.2 Observatories
    - TX08.2.1 Mirror Systems

Target Destination

Outside the Solar System